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MILITARY STANDARD

INTEROPERABILITY AND PERFORMANCE STANDARDS FOR DIGITAL LOS MICROWAVE RADIO EQUIPMENT

AMSC N/A

AREA TCTS/SLHC

DEPARTMENT OF DEFENSE
Washington, DC 20301

Interoperability and Performance Standards for Digital LOS Microwave Radio Equipment

MIL-STD-188-145

1. This Military Standard is approved and mandatory for use by all departments and agencies of the Department of Defense in accordance with the OUSDR&E Memorandum, dated 16 August 1983 (see appendix A).

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data that may be of use in improving this document should be addressed to: Director, U.S. Army Information Systems Engineering and Integration Center, ATTN: ASBI-SST, Fort Huachuca, Arizona 85613-7300 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter.

FOREWORD

1. Originally, Military Standard 188 (MIL-STD-188) covered technical standards for tactical and long-haul communications, but later evolved through revisions (MIL-STD-188A, MIL-STD-188B) into a document applicable to tactical communications only (MIL-STD-188C).

2. The Defense Communications Agency (DCA) published DCA Circulars (DCACS) promulgating standards and engineering criteria applicable to the long-haul Defense Communications System (DCS) and to the technical support of the National Military Command System (NMCS).

3. As a result of a Joint Chiefs of Staff (JCS) action, standards for all military communications are now being published in a MIL-STD-188 series of documents. The MIL-STD-188 series is subdivided into a MIL-STD-188-100 series covering common standards for tactical and long-haul communications, a MIL-STD-188-200 series covering standards for tactical communications only, and a MIL-STD-188-300 series covering standards for long-haul communications only. Emphasis is being placed on developing common standards for tactical and long-haul communications published in the MIL-STD-188-100 series.

4. This document contains technical standards and design objectives for digital line-of-sight (LOS) microwave radio equipment. Military multichannel communications systems are being converted to digital synchronous operation in a series of separate, but related, projects which will eventually replace most of the existing inventory analog assets. During the transition period, digital transmission facilities will be required to interoperate with a mix of analog and digital equipment.

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1. SCOPE

1.1 **Purpose.** The purpose of this document is to set forth mandatory interoperability and performance standards, as well as design objectives for new long-haul and tactical digital line-of-sight (LOS) microwave radio equipment. This document is intended for use in conjunction with other applicable system-oriented documents such as specifications and military handbooks. It is not the purpose of this document to serve as a stand-alone comprehensive reference that contains all technical parameters and other details that are required for the design of new equipment or the preparation of specifications. Statements of such parameters and details are governed by the policies of Department of Defense (DoD) Directive (DODD) 5000.43.

1.2 **Application.** This document applies to the design and development of new digital LOS microwave radio equipment for use in multichannel communications systems.

1.3 **System standard and design objective (DO).** The terms “system standard” and “design objective” are defined in the current edition of FED-STD-1037. In this document, the word "shall" identifies mandatory system standards. The word “should” identifies design objectives that are desirable but not mandatory.

2. REFERENCED DOCUMENTS

2.1 **Government documents.**

2.1.1 **Standards and handbooks.** Unless otherwise specified, the following standards and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation form a part of this standard to the extent specified herein.

STANDARDS

FEDERAL

FED-STD-1037 Glossary of Telecommunication Terms

MILITARY

MIL-STD-188-114 Electrical Characteristics of Digital Interface Circuits

MIL-STD-188-115 Subsystem Design and Engineering Standards for Communications Timing and Synchronization

MIL-STD-188-124 Grounding, Bonding and Shielding for Common Long Haul/Tactical Communication Systems Including Ground Based Communications-Electronics Facilities and Equipments

MIL-STD-188-200 System Design and Engineering Standards for Tactical Communications

MIL-STD-461 Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference

HANDBOOKS

MILITARY

MIL-HDBK-411 Power and Environmental Control for the Physical Plant of DoD Long Haul Communications

2.1.2 **Other Government documents and publications.** The following other Government documents and publications form a part of this standard to the extent specified herein.

DEPARTMENT OF DEFENSE

DODD 5000.43 Acquisition Streamlining

NATIONAL SECURITY AGENCY

NACSEM 5201 (C) TEMPEST Guidelines for Equipment/System Design (U)

NACSIM 5100	(C) Compromising Emanations Laboratory Test Requirements, Electromagnetics (U)

(Copies of specifications, standards, handbooks, drawings, and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 **Other publications.** The following documents form a part of this standard to the extent specified herein. Unless otherwise specified the issues of the documents that are DoD adopted shall be those listed in the issue of the DODISS specified in the solicitation. The issues of documents that have not been adopted shall be those in effect on the date of the cited DODISS.

NORTH ATLANTIC TREATY ORGANIZATION (NATO) STANDARDIZATION AGREEMENTS (STANAGS)

STANAG 4206 series - The NATO Multi-Channel Tactical Digital Gateway (consists of STANAG 4206 through STANAG 4213)

(Copies of STANAGs required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.3 **Order of precedence.** In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

3. DEFINITIONS

3.1 **Definitions.** Definition of terms used in this document shall be as specified in the current edition of FED-STD-1037.

3.2 **Abbreviations and acronyms.** Abbreviations and acronyms used in this document are listed in appendix B.

4. GENERAL REQUIREMENTS

4.1 **Introduction.** A microwave link transfers information in electrical form from one point to another by means of a microwave radio signal. The microwave transmitter accepts a digital data signal input and produces an analog radio frequency (rf) electromagnetic signal output. The microwave receiver accepts the analog rf electromagnetic signal from the transmitter via the propagation path and produces a digital data signal output. The purpose of the interoperability standards is to standardize the digital data and analog rf electromagnetic signals. The object is to enable microwave links to operate integrally with other microwave links and links that utilize other transmission media within long-haul and tactical communications systems. The purpose of the performance standards is to establish parameters that will ensure that the output digital data signals replicate the input digital data signals. Figure 1 illustrates a typical digital LOS microwave radio link.

4.2 **Description of a digital LOS microwave radio set.** A microwave radio link is made up of two microwave sets, one at each end of an LOS propagation path. If LOS propagation cannot be achieved between the two microwave sets, then the link will include a microwave repeater, or repeaters, to provide tandem LOS propagation paths. Each digital microwave set (in the conventional duplex configuration) accepts and delivers a transmission bit stream (TBS), a clock bit stream (CBS), and a service channel bit stream (SCBS). The SCBS includes monitor, alarm, and control data bit streams. Figure 2 shows the composition of a digital LOS microwave radio terminal set.

4.3 **Frequency bands.** The microwave radios shall operate in one or more of the Government frequency allocation bands shown in table I. Within the Government bands, the operating bands and frequencies shall be as specified by the Military Communications-Electronics Board (MCEB). Although the term "microwave" is generally recognized as applying to frequencies from 1 to 30GHz, three bands that are actually outside of this range are included in this standard because of the inventory of LOS equipment in these bands for which no other standards exist. Tactical systems shall be capable of operation in the long-haul frequency bands to enable tactical systems to serve as backups to portions of long-haul systems.

TABLE I. Government frequency allocation bands.

Frequency Band	Long-Haul Application	Tactical Application
225 — 400 MHz		X
410 — 420 MHz		X
902 — 928 MHz		X
1.350 — 1.400 GHz		X
1.429 — 1.435 GHz		X
1.710 — 1.850 GHz	X	X
2.200 — 2.290 GHz	X	
4.400 — 4.990 GHz	X	X
7.125 — 8.400 GHz	X	
14.500 — 15.350 GHz	X	X
21.200 — 23.600 GHz		
25.250 — 27.500 GHz		

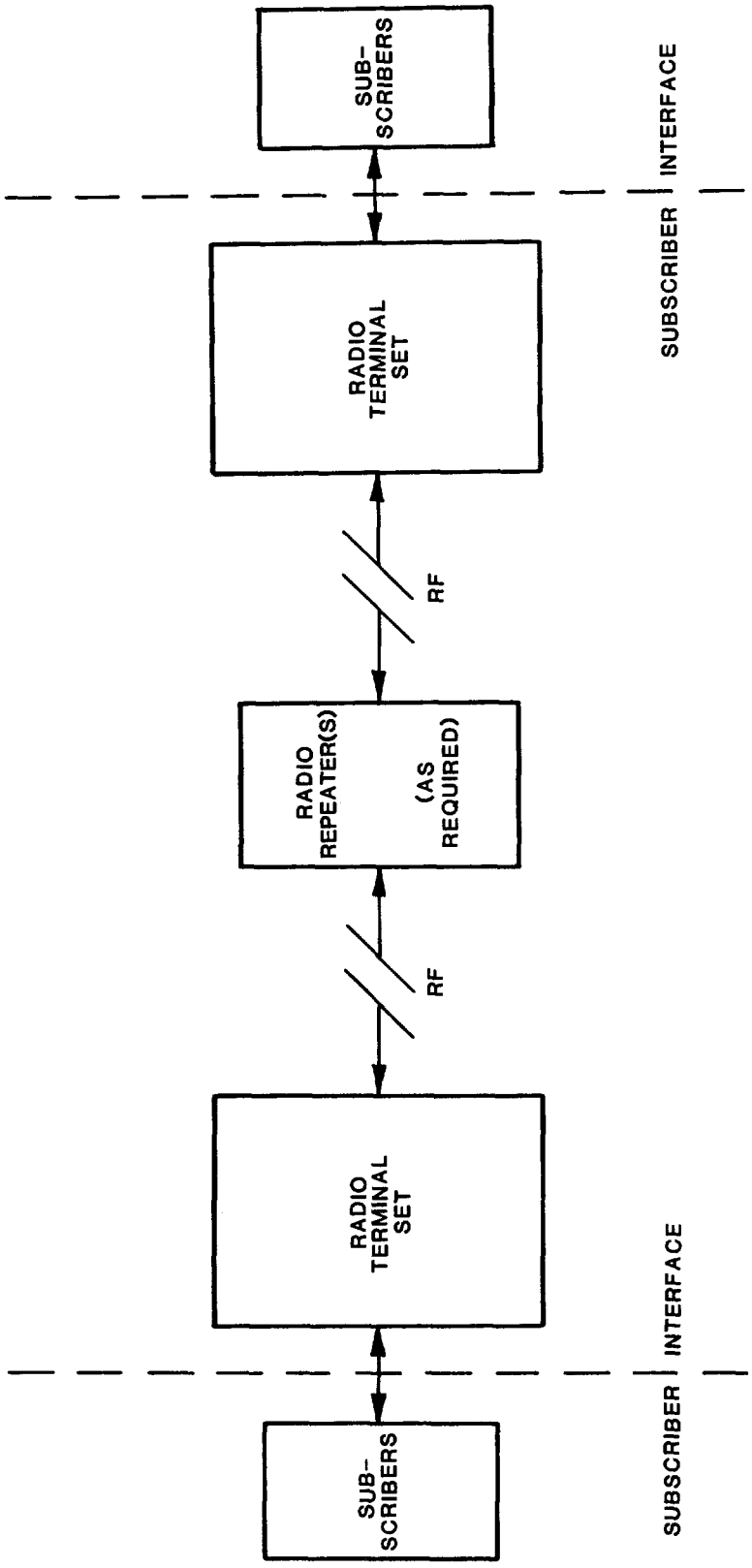


FIGURE 1. Typical digital LOS microwave radio link.

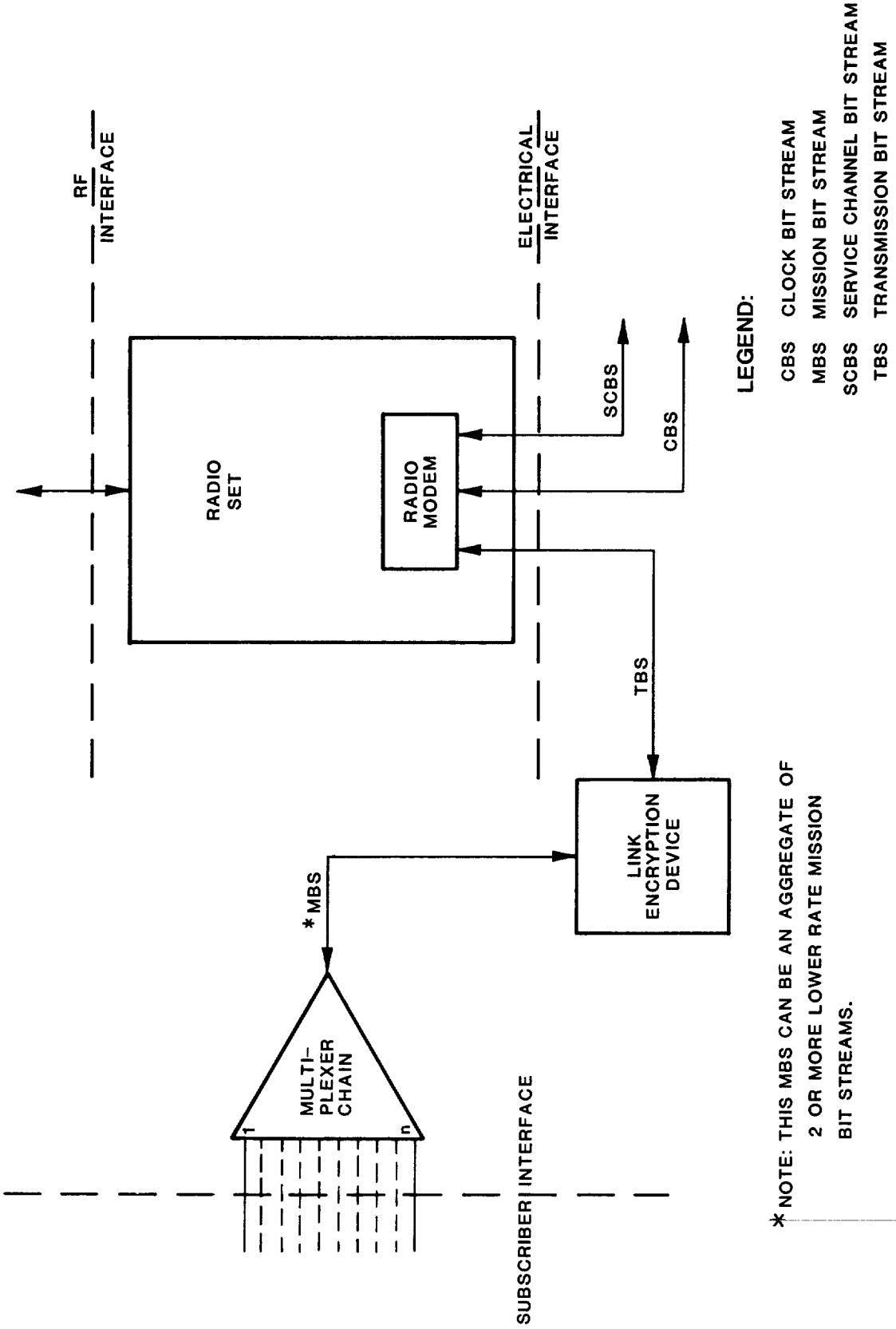


FIGURE 2. Composition of a digital LOS microwave radio terminal set.

4.4 **Equipment reliability.** The mean time between outages (MTBO) for long-haul radio sets shall not be less than 125,000 hours. For tactical systems not configured for hot standby with automatic switchover, the mean time between failures (MTBF) of radio sets shall not be less than 3,000 hours.

4.5 **Electrical interface.** As a minimum, the interfaces for serial data shall be in accordance with the provisions of MIL-STD-188-114. The capability to accept additional interface standards is not precluded.

4.6 **Transmit modulation randomization.** The transmitted data shall be randomized in order to reduce spectral peaks in the transmit spectrum and to assure there are adequate data transitions to allow receiver clock recovery.

4.7 **Logic or signal sense protection.** Frequency translation techniques incorporated by microwave equipment shall not invert the logic or signal sense of data streams.

4.8 **Dispersive propagation.** As a DO, the microwave radio equipment should contain circuitry to reduce the effects of dispersive propagation. The specific operating conditions shall be as defined in the applicable system, subsystem, or equipment specification. For long-haul systems such circuitry can be incorporated as an embedded feature or as an optional add-on.

4.9 **Bit error ratio (BER).** Radio equipment in long-haul applications shall provide a BER better than 10^{-12} on a back-to-back basis at the highest bit rate used. Tactical radio equipment shall provide a BER better than 10^{-10} (DO 10^{-12}) on a back-to-back basis at the highest bit rate used. The duration of the BER measurement for both types of equipment shall be that required for a 95-percent confidence factor or 72-hour minimum. The received signal level (RSL) shall be 40 dB above threshold. Threshold is defined as that RSL which produces a BER of 10^{-3}.

4.10 **Bit-count integrity (BCI).** Since the initial implementation of digital systems in the DCS will use LORAN C signals as its timing source, the microwave equipment shall not reduce the mean time to loss of BCI (MTTLBCI) below that caused by LORAN C propagation outages. In tactical systems, the equipment shall be designed so that interruption of the digital path for 10 seconds or less shall not result in loss of BCI.

4.11 **Timing.** The microwave radio set shall be capable of accepting an external clock that will synchronize and control the clock rates of digital signals at the external interfaces. The radio set shall be capable of operating without external clock when this clock is not provided. The clock signal shall conform to MIL-STD-188-115.

4.12 **Absolute delay equalization.** The microwave radio equipment shall include circuitry to equalize the fixed time delay difference between two diversity paths within 1 nanosecond (ns), for delay differences as long as 1000 ns. The time delay difference between primary and standby transmitting systems shall also be equalized within 1 ns.

4.13 **Other general requirements.** There are other general requirements that must be met by LOS microwave equipment. As these requirements are detailed in other documents, they will not he restated here. The following is a listing of these other requirements and the appropriate reference document.

a. Communications security. MIL-STD-188-200.
h. Compromising emanations. NACSEM 5201 and NACSIM 5100.
c. Electromagnetic compatibility. MIL-STD-461.
d. Electronic warfare and electronic counter-countermeasures. MIL-STD-188-200.
e. Environmental control. MIL-HDBK-411.
f. Grounding, bonding and shielding. MIL-STD-188-124.
g. NATO interfaces. STANAG 4206 series.
h. Primary electric power. MIL-HDBK-411.

5. DETAILED REQUIREMENTS

5.1 **Rf bandwidth.** Table II lists bandwidths used to transmit various numbers of digroups (1.544-Mbps bit streams) and their associated SCBSs and overhead bits. The bandwidths listed in this table are the maximum for use within the United States and its territories. Elsewhere, the maximum bandwidths shall be as authorized by the host-nation government.

TABLE II. Maximum bandwidths for microwave radio.

Digroup Capacity	Maximum Bandwidth (MHz)	Design Objective (MHz)
2	3.5	1.8
4	3.5	1.8
6	7.0	3.5
8	7.0	3.5
12	10.5	7.0
16	14.0	10.0
28		14.0
56		20.0

5.2 **Rf stability.** The transmitter and receiver rf stability shall be as shown in table III.

TABLE III. Radio frequency stability.

Band	Rf stability in parts-per-million
225 — 400 MHz	5
410 — 420 MHz	2.5
902 — 928 MHz	5
1.350 — 1.400 GHz	30
1.429 — 1.435 GHz	30
1.710 — 1.850 GHz	30
2.200 — 2.290 GHz	30
4.400 — 4.990 GHz	50
7.125 — 8.400 GHz	50
14.500 — 15.350 GHz	50
21.200 — 23.600 GHz	50
25.250 — 27.500 GHz	50

5.3 **Emission mask.** The requirements stated herein apply within the United States and its territories. Equipment to be employed outside of this Jurisdiction will meet the certification of the host nation.

5.3.1 **Bands 225-400 MHz, 902-928 MHz, 1.35-1.40 GHz, and 1.429-1.435 GHz.** The mean power of any spurious emission supplied to the antenna transmission line, as compared with the mean power of the fundamental output, shall be in accordance with the following limitations:

a. The spurious emission shall be at least 25 dB below the fundamental output on any frequency removed from the assigned frequency by more than 75 percent up to and including 150 percent of the authorized bandwidth.

b. The spurious emission shall be at least 35 dB below the fundamental output on any frequency removed from the assigned frequency by more than 150 percent up to and including 300 percent of the authorized bandwidth.

c. On any frequency removed from the assigned frequency by more than 300 percent of the authorized bandwidth, the spurious emission shall be at least 43 plus 10 $\log_{10}$ (mean power of the fundamental output in watts) dB below the fundamental output.

5.3.2 **Bands 410-420 MHz, 1.71-1.85 GHz, 2.20-2.29 GHz, 4.40-4.99 GHz, 7.125-8.400 GHz, and 14.50-15.35 GHz.**

a. The spurious emissions shall be attenuated below the fundamental output as specified in the following formula. This applies in any 4-kHz segment, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth. In any case, the attenuation shall be no less than 50 dB.

$$A = 35 + 0.8 (\% - 50) + 10 \log BW$$

where:

A = attenuation (in dB) below the mean output power level

% = percent of the authorized bandwidth removed from the assigned frequency

BW = authorized bandwidth in Mhz

Attenuation greater than 80 dB is not required.

b. In any 4-kHz segment, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth, the spurious emissions shall be attenuated below the fundamental output by at least 43 plus 10 $\log_{10}$ (mean power of the fundamental output in watts) dB. Attenuation greater than 80 dB is not required.

5.3.3 **Bands 21.2-23.6 GHz and 25.25-27.50 GHz.**

a. The spurious emissions shall be attenuated below the fundamental output as specified in the following formula. This applies in any 1-MHz segment, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth. In any case, the attenuation shall be no less than 11 dB.

$$A = 11 + 0.4 (\% - 50) + 10 \log BW$$

where:

A = attenuation (in dB) below the mean output power level

% = percent of the authorized bandwidth removed from the assigned frequency

BW = authorized bandwidth in Mhz

Attenuation greater than 56 dB is not required.

b. In any 4-kHz segment, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth, the spurious emissions shall be attenuated below the fundamental output by at least 43 plus 10 $\log_{10}$ (mean power of the fundamental output in watts) dB. Attenuation greater than 80 dB is not required.

5.4 **Co-channel interference.** The receiver BER performance at a given signal input level shall not be degraded by more than I dB when an interfering signal at the receiving frequency is applied to the receiver input at a level 30 dB below the level of the desired signal.

5.5 **Bit rates.** As a minimum, the microwave radio equipment shall have the capability to input and output any of the following bit rates:

a. 1.544 Mbps (Level 1, 1 digroup).

b. Even-numbered multiples of the digroup rate, plus the overhead bit rate (Level 2, 2 to 8 digroups).

c. 44.736 Mbps (Level 3, 28 digroups) (not required for low capacity systems).

d. 192 kbps (SCBS).

e. 576 kbps and 2304 kbps (tactical interfaces).

f. 512 kbps (NATO interface).

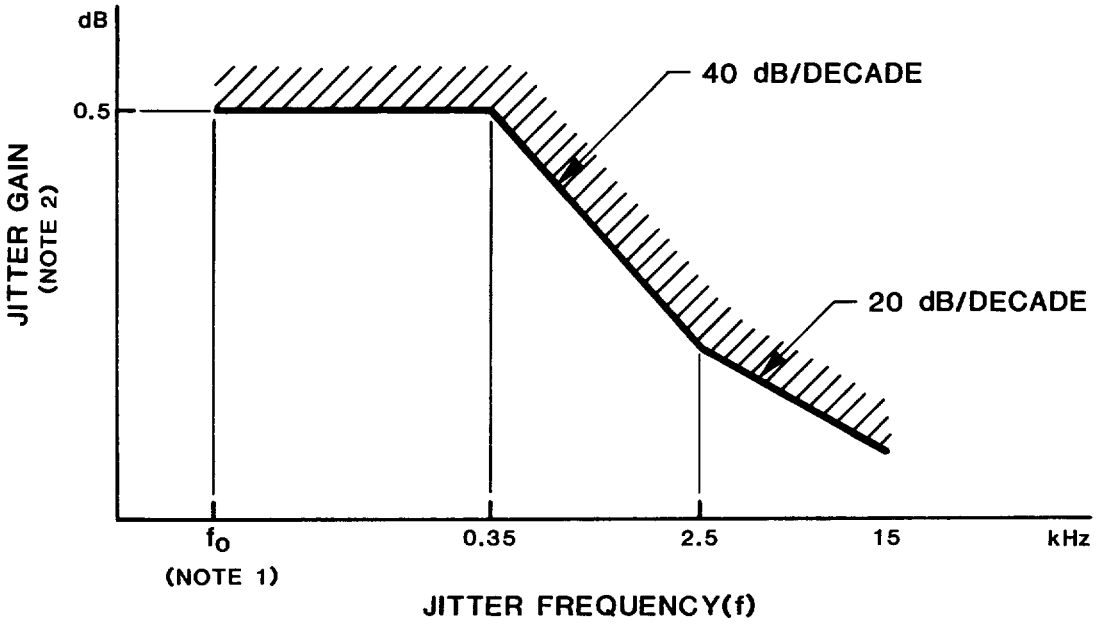
5.6 **Jitter.**

5.6.1 **Intrinsic jitter.** Intrinsic jitter of the microwave radio equipment is not standardized.

5.6.2 **Jitter transfer characteristic.** The jitter transfer characteristic of the microwave radio equipment at 1.544 Mbps shall be within the limits defined by the mask of figure 3. Other bit rates are not standardized.

5.6.3 **Jitter and wander tolerance.** At bit rates of 1.544 and 44.736 Mbps, the microwave radio equipment shall be capable of accepting jitter and wander up to the limits defined by the mask of figure 4. Other bit rates are not standardized.

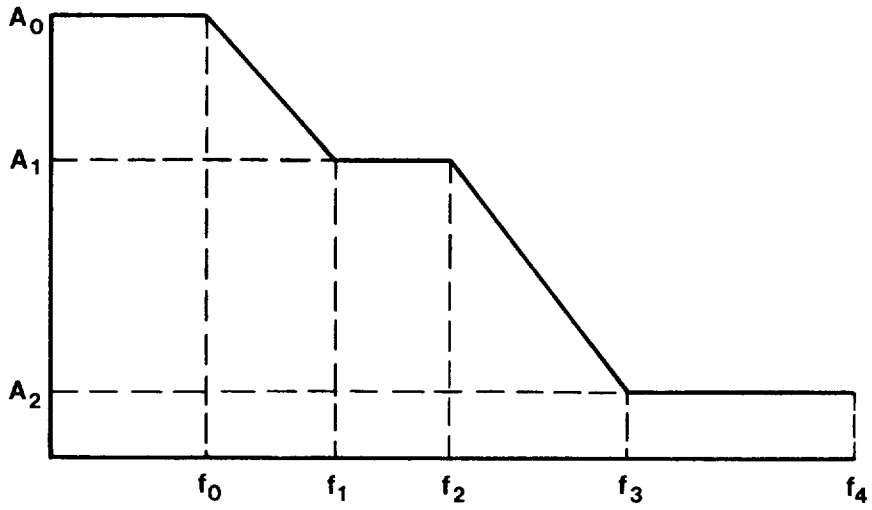
5.7 **Intermodulation products.** The companion transmitter intermodulation products shall not degrade receiver threshold performance by more than 1 dB nor impose restrictions on receiver frequency assignments in frequency diversity systems. Receiver threshold is defined as the signal input level below which the receiver output BER is worse than 10^{-3} at the highest data rate.



NOTES:
1. THE FREQUENCY f_O SHOULD BE AS LOW AS POSSIBLE TAKING INTO ACCOUNT THE LIMITATIONS OF MEASURING EQUIPMENT.
2. JITTER GAIN IS DEFINED AS THE RATIO OF OUTPUT JITTER AMPLITUDE TO INPUT JITTER AMPLITUDE.

FIGURE 3. 1.544 Mbps demultiplexer jitter transfer characteristic.

5.8 **Diversity and hot standby.** The microwave radio equipment shall be capable of operation in the diversity mode. Diversity operation shall be used in long-haul systems. The use of diversity in tactical systems will depend on the tactical situation. Microwave terminals in long-haul systems shall be configured for hot standby using failure-sensing and automatic switching circuitry. Hot standby switchover shall occur within 100 ns after failure of the on-line unit has been sensed.



(a) MASK OF TOLERABLE SINUSOIDAL JITTER AND WANDER

DIGITAL EQUIPMENT INPUT JITTER AND WANDER TOLERANCE

PARAMETER VALUES / BIT RATES Mbps	PEAK-TO-PEAK JITTER AMPLITUDE (UI) (NOTE 1)			FREQUENCY (Hz)				
	A_0 [μs] (NOTE 2)	A_1	A_2	f_0	f_1	f_2	f_3	f_4
1.544	18	5	0.1	12×10^{-6}	10	500	8k	40k
44.736	18	5	0.1	12×10^{-6}	10	2.3k	60k	300k

NOTES:

1. UI = UNIT INTERVAL
2. μs = MICROSECONDS

   FOR 1.544 Mbps: 18μs = 28 UI

   FOR 44.736 Mbps: 18μs = 805 UI

FIGURE 4. Tolerable jitter and wander mask.

6. NOTES

6.1 **Intended use.** This standard specifies minimum interoperability and performance characteristics for digital line-of-sight microwave radio equipment to be used in the design and installation of new communications systems and in the authorized upgrading or rehabilitation of existing systems.

6.2 **Subject term (key word) listing:**

Bands, frequency

Bandwidth, radio frequency

Bit-count integrity (BCI)

Bit error ratio (BER)

Bit rates

Diversity

Emission mask

Equalization, delay, absolute

Interface, electrical

Interference, co-channel

Intermodulation products

Jitter

Propagation, dispersive

Reliability, equipment

Stability, radio frequency

Standby, hot

APPENDIX A

MEMORANDUM FROM THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING 16 AUGUST 1983, SUBJECT: MANDATORY USE OF MILITARY TELECOMMUNICATIONS STANDARDS IN THE MIL-STD-188 SERIES

This appendix contains information related to MIL-STD-188-145. Appendix A is a mandatory part of this standard.

THE UNDER SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

RESEARCH AND ENGINEERING

16 AUG 1983

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (INSTALLATIONS, LOGISTICS & FINANCIAL MANAGEMENT)
ASSISTANT SECRETARY OF THE NAVY (SHIPBUILDING & LOGISTICS)
ASSISTANT SECRETARY OF THE AIR FORCE (RESEARCH DEVELOPMENT & LOGISTICS)
COMMANDANT OF THE MARINE CORPS
DIRECTOR, DEFENSE COMMUNICATIONS AGENCY
DIRECTOR, NATIONAL SECURITY AGENCY

SUBJECT: Mandatory Use of Military Telecommunications Standards in the MIL-STD-188 Series

On May 10, 1977, Dr. Gerald Dinneen, then Assistant Secretary of Defense(c3l), issued the following policy statement regarding the mandatory nature of the MIL-STD-188 series telecommunications standards:

"...standards as a general rule are now cited as 'approved for use' rather than 'mandatory for use' in the Department of Defense.

This deference to the Judgment of the designing and procuring agencies is clearly appropriate to standards dealing with process, component ruggedness and reliability, paint finishes, and the like. It is clearly not appropriate to standards such as those in the MIL-STD-188 series which address telecommunication design parameters. These influence the functional integrity of telecommunication systems and their ability to efficiently interoperate with other functionally similar Government and commercial systems. Therefore, relevant military standards in the 188 series will continue to be mandatory for use within the Department of Defense.

To minimize the probability of misapplication of these standards, it is incumbent upon the developers of the MIL-STD-188 series to insure that each standard is not only essential but of uniformly high quality, clear and concise as to application, and wherever possible compatible with existing or proposed national, international and Federal telecommunication standards. It is also incumbent upon the users of these standards to cite in their procurement specifications only those standards which are clearly necessary to the proper functioning of the device or systems over its projected lifetime."

This statement has been reviewed by this office and continues to be the policy of the Department of Defense.

APPENDIX B

ABBREVIATIONS AND ACRONYMS

10. GENERAL.

10.1 **Scope.** This appendix contains a list of abbreviations and acronyms used in MIL-STD-188-145.

10.2 **Application.** This appendix is a nonmandatory part of MIL-STD-188-145.

ac	alternating current
BER	bit error ratio
BERT	bit error ratio tester
BCI	bit-count integrity
CBS	clock bit stream
dB	decibel
DCA	Defense Communications Agency
DCAC	Defense Communications Agency Circular
DCS	Defense Communications System
DO	design objective
DoD	Department of Defense
DODD	Department of Defense Directive
DODISS	Department of Defense Index of Specifications and Standards
Ghz	gigahertz (10^9 hertz)
Hz	hertz
IMD	intermodulation distortion
JCS	Joint Chiefs of Staff
kbps	kilobit per second (10^3 bits per second)
kHz	kilohertz (10^3 hertz)
log	logarithm

LORAN	long range electronic navigation
LOS	line-of-sight
Mbps	megabit per second (10^6 bits per second)
MBS	mission bit stream
MCEB	Military Communications-Electronics Board
Mhz	megahertz (10^6 hertz)
μS	microsecond (10^{-6} seconds)
MTBF	mean time between failures
MTBO	mean time between outages
MTTLBCI	mean time to loss of bit-count integrity
NACSEM	National Communications Security COMSEC/EMSEC Memorandum
NACSIM	National Communications Security Information Memorandum
NATO	North Atlantic Treaty Organization
NMCS	National Military Command System
ns	nanosecond (10^{-9} seconds)
Pe	probability of error
rf	radio frequency
RSL	received signal level
SCBS	service channel bit stream
STANAG	Standardization Agreement (NATO)
TBS	transmission bit stream
UI	unit interval
UUT	unit under test

APPENDIX C

TESTING

10. SCOPE. This appendix provides test methods for the standardized parameters. This appendix Is a nonmandatory part of MIL-STD-188-145.

20. GENERAL. All test equipment must be properly calibrated. Any necessary grounding of test equipment and unit under test (UUT) shall be made to a single grounding point to prevent ground loops. A filtered ac power source should be used for the test equipment wherever possible. The accuracy of all connections and switch positions must be verified before the UUT is connected to the measuring equipment. Unbalanced test equipment shall be bridged through an isolation transformer for those UUTs with balanced circuits. The UUT, associated circuits, and test equipment should be carefully checked for proper impedance match each time a test connection is made.

20.1 **Bit error ratio (BER).**

20.1.1 **Scope.** Bit errors occur when receiving circuitry detects the opposite binary state from that of the transmitted signal. BER Is the ratio of erroneous bits to total transmitted bits in a specified period of time.

20.1.2 **Method.** BER measurements are made by transmitting a known bit sequence through the UUT and making a bit-by-bit check of the resulting output. Measurements are generally made with a bit error ratio tester (BERT). Measurement periods are normally to the 95-percent confidence factor or 72 hours.

20.2 **Bit-count integrity (BCI).**

20.2.1 **Scope.** Mean time to loss of bit-count integrity (MTTLBCI) measurements apply to digital systems that are subject to loss of synchronization.

20.2.2 **Method.** Occurrences of BCI loss can be counted by an event counter during a period that is specified by the MTTLBCI allocation for the UUT. At the end of the required test period, the MTTLBCI is computed and compared to the MTTLBCI allocation. Loss of synchronization can also be determined by the use of one BERT in a looped test system or two BERTs in a full duplex test system.

20.3 **Hot standby switchover time.**

20.3.1 **Scope.** The time required to reestablish connectivity after switching to a hot standby unit has a significant effect upon system efficiency. If the switchover time is sufficiently short, the switchover can be accomplished without loss of BCI.

20.3.2 **Method.** Two transmitters and two receivers are connected in a hot standby system configuration. Each transmitter and each receiver is made to fall successively in the on-line position. The elapsed time from the initiation of failure of the operating unit to the resumption of the signal path through the standby unit is measured.

20.4 **Timing.**

20.4.1 **Scope.** The internal independent clock system must function without causing system degradation attributable to the clock accuracy or stability.

20.4.2 **Method.** Measurement of timing accuracy does not depend on the duration of the test. Measurement of timing stability, however, requires a time duration dimension. The length of the stability test observation and the

maximum allowable frequency deviation depend upon the performance specification for the UUT. The test instruments must have an accuracy and stability at least five times greater than the requirement for the UUT.

20.5 **Radio frequency stability.**

20.5.1 **Scope.** This test is used to measure the rf stability of microwave transmitters and receivers.

20.5.2 **Method.** Measurement of rf stability requires a time duration dimension. The length of the test period is based upon the UUT performance specifications. Some equipment may require that the modulation bit stream be removed for this test so that the transmitter is unmodulated. (NOTE: The randomizer may give a constant output.) Frequency measuring test equipment must have an accuracy and stability at least five times greater than that of the UUT.

20.6 **Bandwidth and emission mask.**

20.6.1 **Scope.** This test measures the transmission bandwidth for correlation with a particular data rate; that is, digroup capacity as shown in table 11. It will further determine whether operation is within the required emission mask.

20.6.2 **Method.** The bandwidth of the transmitted signal is measured and compared to the authorized bandwidth. The signal is measured for suppression of spurious emissions as determined by the emission mask requirements.

20.7 **Co-channel interference.**

20.7.1 **Scope.** This type of interference generally results from two or more transmitters operating on the same rf channel. A frequent cause is overshoot resulting from reuse of frequency assignments. In tandem links, rf energy transmitted from one site can overshoot intervening sites and enter a distant site receiver operating on the same channel. Even though this overshooting energy may contain the same information as that of the desired signal at that distant site, path delay differences between those signals can result in destructive interference.

20.7.2 **Method.** This test uses two simulated traffic signals to represent the desired and interfering signals respectively. Both the simulated desired signal and the simulated interfering signal should be of the same coding format. Accurate measurement requires test signals with high amplitude stability.

20.8 **Jitter.**

20.8.1 **Scope.** Jitter is defined as abrupt and spurious variations in a signal such as in internal duration, amplitude of successive cycles, or in the frequency or phase of successive pulses. The three principal parameters of interest for digital microwave radio equipment are:

a. Intrinsic jitter. The amount of self-generated jitter produced by the equipment under test.

b. Jitter transfer characteristic. The proportion of input jitter that an equipment unit passes through to its output.

c. Jitter and wander tolerance. The maximum amount of sinusoidal Jitter or wander that can be applied to the input of digital equipment before the onset of transmission errors.

20.8.2 **Method.** The digital test signal shall represent normal digital traffic by having adequate spectral content within the jitter bandwidth of the equipment under test.

a. Intrinsic Jitter. A jitter generator/receiver is interfaced to the UUT. A demodulated output jitter signal is fed to a swept test unit such as a frequency selective level meter for analysis. The information collected is then plotted as peak-to-peak jitter versus jitter frequency.

b. Jitter transfer characteristic. This test is completed on a loopback basis. In this test a specified amount of jitter (both amplitude and frequency) is applied to the UUT. The amplitude of the jitter that appears at the output of the equipment, at the applied jitter frequency, is then measured. The information thus collected is then plotted to show the applied jitter versus frequency and the measured output jitter versus frequency.

c. Jitter and wander tolerance. In this test a jittered pseudorandom test pattern is applied to the looped UUT. The amplitude of the induced jitter is incrementally increased, starting from zero bits peak-to-peak, until transmission errors are detected. This process is repeated over a range of jitter frequencies (< 1 Hz for wander;.≥ 1 Hz for jitter). The range of values permits a plot of jitter frequency versus maximum allowable input jitter amplitude to be constructed for the equipment tinder test.

20.9 **Transmitter intermodulation distortion (IMD).**

20.9.1 **Scope.** This test method is used to determine the rf isolation between companion transmitters and receivers by measuring the spurious signals that have been introduced into the receiver by the companion transmitter.

20.9.2 **Method.** Rf isolation between companion transmitters and receivers is important, since transmitters may introduce spurious signals into the allocated bandwidth of their companion receiver. These spurious signals may cause interference with normal received rf and baseband signals. For this test a pseudorandom signal that closely approximates the normal traffic spectrum content should be used as the traffic simulation signal. The test will be performed over the entire allocation of transmitter/receiver frequency combinations. At each test frequency, plot the BER or probability of error (Pe) versus the RSI. with the companion transmitter off. With the transmitter on, compare the resultant Pe/RSI, curve with the previous one. Measure the shift.

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